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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

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APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. X Specification [Total Pages 31]
2. X Drawing(s) (35USC 113) [Total Pages 3]
3. X Declaration and Power of Attorney [Total Pages 3]
   a. x Executed declaration
   b. __ Copy from prior application (37CFR 1.63(d)) *(for continuation/divisional with Box 14 completed)*
      [Note Box 4 Below]
      i. __ DELETION OF INVENTOR(S) Signed statement attached deleting Inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
4. __ Incorporation By Reference (usable if Box 3b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 3b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

ACCOMPANYING APPLICATION PARTS

5. X Assignment Papers (cover sheet & documentation) Honeywell International Inc.
6. __ Letter under 37 CFR 1.41(c).
7. __ English Translation Document *(if applicable)*
8. __ Information Disclosure Statement (IDS)/PTO-1449 __ Copies of IDS Citations
9. __ Preliminary Amendment
10. X Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
11. __ Small Entity Statement(s) __ Statement filed in prior application, Status still proper and desired
12. __ Certified Copies of Priority Document(s)
13. ___ Other:

14. If a CONTINUING APPLICATION, *check appropriate box and supply the requisite information:*
__ Continuation __ Divisional __ Continuation-in-part (CIP) __ of prior application No: /

CLAIMS AS FILED

(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) BASIC FEE $740 00
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X The Commissioner is hereby authorized to charge any additional fees which may be required in connection with this application, or credit any overpayment to ACCOUNT NO. 501-519. A duplicate copy of this sheet is enclosed.

X A check in the amount of $ 1004.00 to cover the filing fee is enclosed.

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BOX PATENT APPLICATION
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Case Number: P01,0367 (H0002254)

Inventor: Hong Wan

Patent Application:

"INTEGRATED MAGNETIC FIELD STRAP FOR SIGNAL ISOLATOR"

Signature of person mailing documents and fee

Craig G. Thornton

INTEGRATED MAGNETIC FIELD STRAP FOR SIGNAL ISOLATOR

Technical Field of the Invention

The present invention relates to a magnetic signal isolator and, more particularly, to a magnetic field strap for an integrated signal isolator.

Background of the Invention

Signal isolators are typically used to isolate lower voltage circuits from relatively higher voltage circuits. For example, it is frequently desirable to isolate a group of sensors being operated in a relatively higher voltage range from processing being operated in a lower voltage range.

Transformers and optical systems have been used as signal isolators. Transformers are usually rather bulky devices when compared with other electronic components associated with integrated circuits. Therefore, transformers are provided externally of the integrated circuits with which they are used.

Optical isolation is usually accomplished by modulating the signal emitted by an optical emitting device, such as a light emitting diode, in accordance with the signal being processed. The emitting device used in such a system is positioned so that the radiation it emits strikes a detector. The output of the detector is then transferred

to a processing circuit. In systems that use plural optical isolators, it is difficult, without the use of a complicated assembly, to prevent radiation emitted by one emitter device from striking other detectors located. Therefore, only one such detector, and hence only one optical isolation device, is usually used in a single package. Optical isolation has not been integrated with electronic components.

It is known to integrate a magnetic signal isolator on an integrated circuit. A magnetic signal isolator usually involves a magnetic sensor and a strap. The magnetic sensor may comprise one or more magnetoresistors, and the strap may comprise one or more straps. The strap is coupled to the input of the magnetic isolator and generates a magnetic field in response to an input signal. The magnetic sensor senses this magnetic field and produces an output signal as a function of the magnetic field. Accordingly, the strap receives an input signal from a first circuit operating at a first voltage level, and the magnetic sensor responds to the magnetic field by producing an output signal in a second circuit operating at a second voltage level, which may be either lower or higher than the first voltage level.

The magnetic sensors of known magnetic signal isolators unfortunately sense not only the magnetic field generated by the strap, but also external magnetic fields.

As a consequence, these external magnetic fields introduce an error into the output signal of the magnetic sensor. The present invention is directed to strap and magnetic sensor arrangement that is substantially immune to external magnetic fields.

Summary of the Invention

In accordance with one aspect of the present invention, an integrated signal isolator has first and second ends and comprises first and second isolator input terminals, first and second isolator output terminals, first and second power supply terminals, first, second, third, and fourth magnetoresistors, and an input strap. The first and second magnetoresistors are coupled to the first isolator output terminal, the second and third magnetoresistors are coupled to the first supply terminal, the third and fourth magnetoresistors are coupled to the second isolator output terminal, and the first and fourth magnetoresistors are coupled to the second supply terminal. The input strap has at least one turn coupled between the first and second isolator input terminals. The input strap is disposed with respect to the first, second, third, and fourth magnetoresistors so that a magnetic field is generated over two of the magnetoresistors in one direction, so that a magnetic field is generated over the other two of the

magnetoresistors in an opposite direction, and so that, when input current flows between the first and second isolator input terminals, a resistance of the first magnetoresistor tracks a resistance of the third magnetoresistor, and a resistance of the second magnetoresistor tracks a resistance of the fourth magnetoresistor.

In accordance with another aspect of the present invention, an integrated signal isolator has first and second ends and comprises first, second, third, and fourth magnetoresistors and an input strap. The first and second magnetoresistors are coupled to a first isolator output terminal, the second and third magnetoresistors are coupled to a first supply terminal, the third and fourth magnetoresistors are coupled to a second isolator output terminal, and the first and fourth magnetoresistors are coupled to a second supply terminal. Each of the first, second, third, and fourth magnetoresistors has a long dimension extending between the first and second ends. The input strap has at least one turn coupled between first and second isolator input terminals. The at least one turn has a first portion running alongside two of the magnetoresistors and a second portion running alongside the other two magnetoresistors, and the at least one turn is arranged so that current supplied to the input strap flows through the first portion in a first direction between the

first and second ends and through the second portion in a second direction between the first and second ends. The first and second directions are substantially opposite to one another.

In accordance with still another aspect of the present invention, a method of isolating first and second circuits comprising: generating a first field across at least one magnetically responsive element, wherein the first field is generated in response to an isolator input signal from the first circuit; generating a second field across at least another magnetically responsive element, wherein the second field is generated in response to the isolator input signal from the first circuit, and wherein the first and second fields are substantially opposite to one another in direction; and, supplying an isolator output signal to the second circuit, wherein the isolator output signal is derived across the at least two magnetically responsive elements, and wherein the first and second fields are generated so that the isolator output signal is responsive to the isolator input signal that generates the first and second fields but not to an external field.

In accordance with still another aspect of the present invention, a method of making an integrated signal isolator having first and second ends comprises the following: forming first, second, third, and fourth

magnetoresistors in a first layer of an integrated structure so that the first and second magnetoresistors are substantially aligned along a first axis, so that the third and fourth magnetoresistors are substantially aligned along a second axis, and so that the first axis is offset from and parallel to the second axis; coupling the first and second magnetoresistors to a first isolator output terminal; coupling the second and third magnetoresistors to a first supply terminal; coupling the third and fourth magnetoresistors to a second isolator output terminal; coupling the first and fourth magnetoresistors to a second supply terminal; forming an input strap in a second layer of the integrated structure so that the input strap, when receiving an input, generates a field across two of the first, second, third, and fourth magnetoresistors and an opposing field across the other two of the first, second, third, and fourth magnetoresistors; and, coupling the input strap between first and second isolator input terminals.

Brief Description of the Drawings

These and other features and advantages will become more apparent from a detailed consideration of the invention when taken in conjunction with the drawings in which:

Figure 1 illustrates an exemplary magnetic sensor that may be used in a magnetic signal isolator;

Figure 2 illustrates an integrated magnetic signal isolator according to one embodiment of the present invention and incorporating the exemplary magnetic sensor illustrated in Figure 1;

Figure 3 is a cross section of the integrated magnetic signal isolator taken along line 3-3 of Figure 2;

Figure 4 illustrates an integrated magnetic signal isolator according to another embodiment of the present invention and incorporating the exemplary magnetic sensor illustrated in Figure 1; and,

Figure 5 is a cross section of the integrated magnetic signal isolator taken along line 5-5 of Figure 4.

Detailed Description

As shown in Figure 1, an integrated magnetic signal isolator 10 according to one embodiment of the present invention includes a magnetic sensor 12 having magnetoresistors 14, 16, 18, and 20. Each of the magnetoresistors 14, 16, 18, and 20 may comprise a corresponding thin film of a magnetically responsive material, such as Permalloy or a multilayer GMR film such as Co/Cu/Co. A junction 22 between the magnetoresistors 14 and 20 is coupled to a bridge voltage supply, and a junction 24

between the magnetoresistors 16 and 18 is coupled to a reference, such as ground, of the bridge voltage supply. A junction 26 between the magnetoresistors 14 and 16 and a junction 28 between the magnetoresistors 18 and 20 provide the output of the magnetic sensor 12. As can be seen from Figure 1, the magnetic sensor 12 is arranged as a Wheatstone bridge.

As shown in Figures 2 and 3, the magnetic sensor 12 is integrated with an input strap 30 and a set-reset coil 32 to form the integrated magnetic signal isolator 10. The integrated magnetic signal isolator 10 includes a semiconductor substrate 34 over which is formed a dielectric layer 36. The magnetoresistors 14, 16, 18, and 20, which may be provided as permalloy thin films having "barber poles" on the tops thereof, or as GMR multiplayer films, are formed over the dielectric layer 36, and a dielectric layer 38 is formed over the magnetoresistors 14, 16, 18, and 20. Each of the dielectric layers 36 and 38 may comprise, for example, silicon dioxide or silicon nitride.

Barber poles are individual conductors that are deposited at an angle across the magnetoresistive material forming the magnetoresistors. These barber poles cause current to flow at an angle through the magnetoresistors. Alternatively, a Barber-pole configuration may include alternating strips of magnetoresistive material (such as

permalloy) and conductive material. The dimensions of the strips and the dimensions and orientation of the conductive material may be varied to assist in providing the desired performance characteristics.

The input strap 30 includes at least one turn provided on the dielectric layer 38 above the magnetoresistors 14, 16, 18, and 20. With this arrangement, when the input signal is provided to the input strap 30, current flows through the input strap 30 along the magnetoresistors 14 and 16 from an end 40 to an end 42 of the integrated magnetic signal isolator 10, and current flows through the input strap 30 along the magnetoresistors 18 and 20 from the end 42 to the end 40 of the integrated magnetic signal isolator 10, depending on the polarity of the input signal. Thus, the current flows through the input strap 30 and along the magnetoresistors 14 and 16 in one direction, and current flows through the input strap 30 and along the magnetoresistors 18 and 20 in an opposite direction.

A dielectric layer 44 is formed over the input strap 30, and turns of metal are provided on the dielectric layer 44 so as to form the set-reset coil 32. The dielectric layer 44 may comprise, for example, silicon dioxide or silicon nitride. As shown in Figure 2, the turns of the reset coil 32 cross the magnetoresistors 14, 16, 18,

and 20 perpendicularly. Moreover, the turns of the set-reset coil 32 are wound so that they cross the magnetoresistors 14, 16, 18, and 20 in the same orientation. With this arrangement, when the set-reset coil 32 receives a set-reset current pulse, the current that flows through the set-reset coil 32 above the magnetoresistors 14, 16, 18, and 20 flows in the same orientation. The current could be in an opposite direction for half of the bridge if the barber pole orientation is arranged differently. The set-reset pulse is usually provided before an input is provided to the input strap 30 in order to preset the magnetic moments of the magnetoresistors 14, 16, 18, and 20 in a predetermined direction. This predetermined direction is preferably perpendicular to the fields generated by the input strap 30.

By presetting the magnetic moments of each of the magnetoresistors 14, 16, 18, and 20 in the same predetermined orientation, the output provided by the magnetic sensor 12 in response to an input to the input strap 30 is predictable from measurement to measurement of the output of a circuit or sensor coupled to the input strap 30. Thus, the magnetic moments of each of the magnetoresistors 14, 16, 18, and 20 are consistently preset in the same predetermined orientation prior to each measurement.

If the set-reset pulse is applied to the set-reset coil 32 such that current enters terminal 46 and exits terminal 48, a magnetic field is generated having a direction that points from the end 40 to the end 42. If the input signal is applied to the input strap 30 such that current enters terminal 50 and exits terminal 52, a magnetic field is generated across the magnetoresistors 18 and 20 having a direction that points toward a side 54 of the integrated magnetic signal isolator 10. On the other hand, this same current generates a magnetic field across the magnetoresistors 14 and 16 having a direction that points toward a side 56 of the integrated magnetic signal isolator 10.

A dielectric layer 58 is formed over the set-reset coil 32. The dielectric layer 58 may comprise, for example, silicon dioxide or silicon nitride.

With the integrated magnetic signal isolator 10 shown in Figures 1-3, a uniform external magnetic field of any direction does not contribute to the output differential across output terminals 60 and 62 coupled to the junctions 26 and 28, respectively, because the voltages across the magnetoresistors 14 and 20 produced by the external magnetic field track one another as do the voltages across the magnetoresistors 16 and 18. Therefore, any change in the

external magnetic field produces voltage changes at the junctions 26 and 28 that are equal in magnitude and sign.

However, when an input current is applied to the input strap 30, this current generates a magnetic field across the magnetoresistors 14 and 16 that is opposite in direction to the magnetic field generated across the magnetoresistors 18 and 20. These oppositely oriented magnetic fields produce a differential output across the junctions 26 and 28.

Accordingly, a magnetic signal isolator is provided that has an integrated input strap and magnetic sensor and that produces an output that is substantially immune from a uniform external magnetic field of any direction.

According to the embodiment shown in Figures 4 and 5, the magnetic sensor 12 is integrated with an input strap 70 and a set-reset coil 72 to form the integrated magnetic signal isolator 10. The integrated magnetic signal isolator 10 includes a semiconductor substrate 74 over which is formed a dielectric layer 76. The magnetoresistors 14, 16, 18, and 20, which may be provided as permalloy thin films having "barber poles" on the tops thereof, or as GMR multiplayer films, as described above, are formed over the dielectric layer 76, and a dielectric layer 78 is formed over the magnetoresistors 14, 16, 18, and 20.

The input strap 70 comprises a plurality of turns of metal on the dielectric layer 78. As shown in Figure 4, the elongated portions of the turns of the input strap 70 run parallel to the elongated portions of the magnetoresistors 14, 16, 18, and 20. Moreover, the elongated portions of the turns of the input strap 70 extend over the dielectric layer 78 and beyond the magnetoresistors 14, 16, 18, and 20. Metal traces 80 and 82 are coupled to respective ends of the input strap 70.

With this arrangement, when the input signal is provided to the metal traces 80 and 82, current flows through the input strap 70 along the magnetoresistors 14 and 16 from an end 84 to an end 86 of the integrated magnetic signal isolator 10, and current flows through the input strap 70 along the magnetoresistors 18 and 20 from the end 86 to the end 84 of the integrated magnetic signal isolator 10, depending on the polarity of the input signal. Thus, the current flows through the input strap 70 and along the magnetoresistors 14 and 16 in one direction, and current flows through the input strap 70 and along the magnetoresistors 18 and 20 in an opposite direction.

A dielectric layer 88 is formed over the input strap 70, and turns of metal are provided on the dielectric layer 88 so as to form the set-reset coil 72. As shown in Figure 4, the elongated portions of the turns of the reset

coil 72 run perpendicularly to the elongated portions of the magnetoresistors 14, 16, 18, and 20. Moreover, the elongated portions of the turns of the set-reset coil 72 extend over the dielectric layer 88 and beyond the magnetoresistors 14, 16, 18, and 20. Furthermore, the turns of the set-reset coil 72 that are over the magnetoresistors 14 and 20 are wound in a clockwise direction, and the turns of the set-reset coil 72 that are over the magnetoresistors 16 and 18 are wound in a counterclockwise direction, assuming current enters the set-reset coil 72 through a metal trace 90 and exits the set-reset coil 72 through a metal trace 92. The metal traces 90 and 92 are coupled to respective ends of the set-reset coil 72.

With this arrangement, when the metal traces 90 and 92 of the set-reset coil 72 receive a set-reset input, the current that flows through the portion of the set-reset coil 72 above the magnetoresistors 16 and 18 flows in a direction from the magnetoresistor 16 to the magnetoresistor 18, and the current that flows through the portion of the set-reset coil 72 above the magnetoresistors 14 and 20 flows in a direction from the magnetoresistor 14 to the magnetoresistor 20, depending on the polarity of the set-reset pulse.

If the set-reset pulse is applied to the metal traces 90 and 92 such that current enters the set-reset coil

72 at the metal trace 90 and exits the set-reset coil 72 at the metal trace 92, a magnetic field is generated having a direction that points from the end 86 to the end 84. If the input signal is applied to the metal traces 80 and 82 such that current enters the input strap 70 at the metal trace 80 and exits the input strap 70 at the metal trace 82, a magnetic field is generated across the magnetoresistors 18 and 20 having a direction that points toward a side 96 of the integrated magnetic signal isolator 10. On the other hand, this same current generates a magnetic field across the magnetoresistors 14 and 16 having a direction that points toward a side 94 of the integrated magnetic signal isolator 10.

A dielectric layer 98 is formed over the set-reset coil 72.

With the integrated magnetic signal isolator 10 shown in Figures 1, 4, and 5, a uniform external magnetic field of any direction does not contribute to the output differential across metal traces 100 and 102 coupled to the junctions 26 and 28, respectively, because the voltages across the magnetoresistors 14 and 20 produced by the external magnetic field track one another as do the voltages across the magnetoresistors 16 and 18. Therefore, any change in the external magnetic field produces voltage

changes at the junctions 26 and 28 that are equal in magnitude and sign.

However, when an input current is applied to the input strap 70, this current generates a magnetic field across the magnetoresistors 14 and 16 that is opposite in direction to the magnetic field generated across the magnetoresistors 18 and 20. These oppositely oriented magnetic fields produce a differential output across the junctions 26 and 28.

Accordingly, a magnetic signal isolator is provided that has an integrated input strap and magnetic sensor and that produces an output that is substantially immune from a uniform external magnetic field of any direction.

As shown in Figure 4, the magnetoresistor 14 has a plurality of elongated portions 104 coupled end-to-end to form a serpentine structure. The elongated portions 104 of the magnetoresistor 14 are parallel to an axis extending between the ends 84 and 86. Each of the other magnetoresistors 16, 18, and 20 has a similar construction. Moreover, the first and second magnetoresistors 14 and 16 are aligned along a first axis that extends between the ends 84 and 86, and the third and fourth magnetoresistors 18 and 20 are aligned along a second axis that extends between the

ends 84 and 86. These first and second axes are parallel to and offset from one another.

Modifications of the present invention will occur to those practicing in the art of the present invention. For example, the magnetic fields that are generated by the input straps 30,70 across the magnetoresistors 14 and 16 is opposite in direction to the magnetic fields that are generated by the input straps 30,70 across the magnetoresistors 18 and 20. However, opposing fields could be applied to any combination of the magnetoresistors 14, 16, 18, and 20 by suitable re-arrangement of the input straps 30,70 and the set/reset coil. Thus, the magnetic fields that are generated by the input straps 30,70 across the magnetoresistors 14 and 18 may be opposite in direction to the magnetic field that are generated by the input straps 30,70 across the magnetoresistors 16 and 20, or the magnetic fields that are generated by the input straps 30,70 across the magnetoresistors 14 and 20 may be opposite in direction to the magnetic fields that are generated by the input straps 30,70 across the magnetoresistors 16 and 18. By suitable altering the barber poles orientation and the set/reset direction in the AMR film and altering the pinning layer and free layer magnetization directions in the GMR films in the magnetoresistors 14, 16, 18, and 20, the output across the junctions 26 and 28 will track the current

through the input strap 30. Accordingly, the configuration of the barber poles orientation in the AMR films relative to the set/reset direction and configuration of the input strap/magnetoresistor relationship must be such that the change in resistance of the magnetoresistor 14 tracks the change in resistance of the magnetoresistor 18, and such that the change in resistance of the magnetoresistor 16 tracks the change in resistance of the magnetoresistor 20.

Accordingly, the description of the present invention is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which are within the scope of the appended claims is reserved.

WE CLAIM:

1. An integrated signal isolator having first and second ends, wherein the integrated signal isolator comprises:

first and second isolator input terminals;

first and second isolator output terminals;

first and second power supply terminals;

first, second, third, and fourth magnetoresistors, wherein the first and second magnetoresistors are coupled to the first isolator output terminal, wherein the second and third magnetoresistors are coupled to the first supply terminal, wherein the third and fourth magnetoresistors are coupled to the second isolator output terminal, and wherein the first and fourth magnetoresistors are coupled to the second supply terminal; and,

an input strap having at least one turn coupled between the first and second isolator input terminals, wherein the input strap is disposed with respect to the first, second, third, and fourth magnetoresistors so that a magnetic field is generated over two of the magnetoresistors in one direction, so that a magnetic field is generated over the other two of the magnetoresistors in an opposite direction, and so that, when input current flows between the first and second isolator input terminals, a resistance of

the first magnetoresistor tracks a resistance of the third magnetoresistor, and a resistance of the second magnetoresistor tracks a resistance of the fourth magnetoresistor.

2. The integrated signal isolator of claim 1 wherein the at least one turn of the input strap is disposed with respect to the first, second, third, and fourth magnetoresistors so that, when input current flows between the first and second isolator input terminals, a first field is generated across the set/reset direction and two of the first, second, third, and fourth magnetoresistors and a second field is generated across the other two of the first, second, third, and fourth magnetoresistors and so that the first and second fields point in substantially opposite directions thereby producing an output across the first and second isolator output terminals commensurate with the input current.

3. The integrated signal isolator of claim 1 wherein the input strap includes a plurality of turns.

4. The integrated signal isolator of claim 3 wherein each of the first, second, third, and fourth magnetoresistors comprises a serpentine structure having a plurality of elongated magnetoresistive portions coupled end-to-end, wherein the elongated portions of two of the magnetoresistors are position near and in parallel to a first elongated portion of each of the turns of the input strap, wherein the elongated portions of the other two magnetoresistors are position near and in parallel to a second elongated portion of each of the turns of the input strap, and wherein the first elongated portions of the turns of the input strap are parallel to the second elongated portions of the turns of the input strap.

5. The integrated signal isolator of claim 3 wherein each of the first, second, third, and fourth magnetoresistors comprises a serpentine structure having a plurality of elongated magnetoresistive portions coupled end-to-end, wherein the elongated portions of the first and second magnetoresistors are position near and in parallel to a first elongated portion of each of the turns of the input strap, wherein the elongated portions of the third and fourth magnetoresistors are position near and in parallel to a second elongated portion of each of the turns of the input strap, and wherein the first elongated portions of the turns

of the input strap are parallel to the second elongated portions of the turns of the input strap.

6. The integrated signal isolator of claim 1 wherein the first, second, third, and fourth magnetoresistors are in a first layer, wherein the input strap is in a second layer, and wherein the first and second layers are separate layers.

7. The integrated signal isolator of claim 6 further comprising a dielectric between the input strap and the first, second, third, and fourth magnetoresistors.

8. The integrated signal isolator of claim 7 wherein the dielectric is a first dielectric, wherein the integrated signal isolator further comprises a second dielectric over the input strap, and wherein the first, second, third, and fourth magnetoresistors are formed over a substrate and under the first dielectric.

9. The integrated signal isolator of claim 1 further comprising a set-reset coil having a plurality of clockwise turns and a plurality of counterclockwise turns, wherein each clockwise turn of the set-reset coil has a portion running across the first and fourth

magnetoresistors, wherein each counterclockwise turn of the set-reset coil has a portion running across the second and third magnetoresistors, and wherein the clockwise and counterclockwise turns are arranged so that current supplied to the set-reset coil flows through the portions of each of the clockwise and counterclockwise turns in the same direction.

10. The integrated signal isolator of claim 1 further comprising a set-reset coil having a plurality of turns disposed with respect to the first, second, third, and fourth magnetoresistors so that the set-reset coil generates a magnetic field across the first, second, third, and fourth magnetoresistors in the same direction.

11. An integrated signal isolator having first and second ends, wherein the integrated signal isolator comprises:

first, second, third, and fourth magnetoresistors, wherein the first and second magnetoresistors are coupled to a first isolator output terminal, wherein the second and third magnetoresistors are coupled to a first supply terminal, wherein the third and fourth magnetoresistors are coupled to a second isolator output terminal, and wherein

the first and fourth magnetoresistors are coupled to a second supply terminal; and,

an input strap having at least one turn coupled between first and second isolator input terminals, wherein the least one turn has a first portion running alongside two of the magnetoresistors and a second portion running alongside the other two magnetoresistors, wherein the at least one turn is arranged so that current supplied to the input strap flows through the first portion in a first direction between the first and second ends and through the second portion in a second direction between the first and second ends, and wherein the first and second directions are substantially opposite to one another.

12. The integrated signal isolator of claim 11 wherein the input strap includes a plurality of turns.

13. The integrated signal isolator of claim 11 wherein the first, second, third, and fourth magnetoresistors are in a first layer, wherein the input strap is in a second layer, and wherein the first and second layers are separate layers.

14. The integrated signal isolator of claim 11 further comprising a dielectric between the input strap and the first, second, third, and fourth magnetoresistors.

15. The integrated signal isolator of claim 14 wherein the dielectric is a first dielectric, wherein the integrated signal isolator further comprises a second dielectric over the input strap, and wherein the first, second, third, and fourth magnetoresistors are formed over a substrate and under the input strap.

16. The integrated signal isolator of claim 11 further comprising a set-reset coil having a plurality of clockwise turns and a plurality of counterclockwise turns, wherein each clockwise turn of the set-reset coil has a portion running across the first and fourth magnetoresistors, wherein each counterclockwise turn of the set-reset coil has a portion running across the second and third magnetoresistors, and wherein the clockwise and counterclockwise turns are arranged so that current supplied to the set-reset coil flows through the portions of each of the clockwise and counterclockwise turns in the same direction.

17. The integrated signal isolator of claim 11 further comprising a set-reset coil having a plurality of turns disposed with respect to the first, second, third, and fourth magnetoresistors so that the set-reset coil generates a magnetic field across the first, second, third, and fourth magnetoresistors in the same direction.

18. A method of isolating first and second circuits comprising:

generating a first field across at least one magnetically responsive element, wherein the first field is generated in response to an isolator input signal from the first circuit;

generating a second field across at least another magnetically responsive element, wherein the second field is generated in response to the isolator input signal from the first circuit, and wherein the first and second fields are substantially opposite to one another in direction; and,

supplying an isolator output signal to the second circuit, wherein the isolator output signal is derived across the at least two magnetically responsive elements, and wherein the first and second fields are generated so that the isolator output signal is responsive to the isolator input signal that generates the first and second fields but not to an external field.

19. The method of claim 18 wherein the first field is generated across the first and second magnetically responsive elements and the second field is generated across third and fourth magnetically responsive elements, wherein the first and second magnetically responsive elements are coupled to a first isolator output terminal, wherein the second and third magnetically responsive elements are coupled to a first supply terminal, wherein the third and fourth magnetically responsive elements are coupled to a second isolator output terminal, and wherein the first and fourth magnetically responsive elements are coupled to a second supply terminal.

20. The method of claim 18 wherein the first field is generated across the first and third magnetically responsive resistors and the second field is generated across second and fourth magnetically responsive resistors, wherein the first and second magnetically responsive elements are coupled to a first isolator output terminal, wherein the second and third magnetically responsive elements are coupled to a first supply terminal, wherein the third and fourth magnetically responsive elements are coupled to a second isolator output terminal, and wherein

the first and fourth magnetically responsive elements are coupled to a second supply terminal.

21. The method of claim 18 wherein the first field is generated across the first and fourth magnetically responsive resistors and the second field is generated across second and third magnetically responsive resistors, wherein the first and second magnetically responsive elements are coupled to a first isolator output terminal, wherein the second and third magnetically responsive elements are coupled to a first supply terminal, wherein the third and fourth magnetically responsive elements are coupled to a second isolator output terminal, and wherein the first and fourth magnetically responsive elements are coupled to a second supply terminal.

22. The method of claim 18 further comprising setting the magnetic moments of the at least two magnetically responsive elements in the same direction.

23. The method of claim 22 wherein the moment direction is substantially perpendicular to the first and second fields.

24. The method of claim 23 wherein the setting of the magnetic moments is momentary.

25. The method of claim 24 wherein the setting of the magnetic moments comprises setting the magnetic moments prior to generating the first and second fields.

26. A method of making an integrated signal isolator having first and second ends comprising:

forming first, second, third, and fourth magnetoresistors in a first layer of an integrated structure so that the first and second magnetoresistors are substantially aligned along a first axis, so that the third and fourth magnetoresistors are substantially aligned along a second axis, and so that the first axis is offset from and parallel to the second axis;

coupling the first and second magnetoresistors to a first isolator output terminal;

coupling the second and third magnetoresistors to a first supply terminal;

coupling the third and fourth magnetoresistors to a second isolator output terminal;

coupling the first and fourth magnetoresistors to a second supply terminal;

forming an input strap in a second layer of the integrated structure so that the input strap, when receiving an input, generates a field across two of the first, second, third, and fourth magnetoresistors and an opposing field across the other two of the first, second, third, and fourth magnetoresistors; and,

coupling the input strap between first and second isolator input terminals.

27. The method of claim 26 wherein the each of the first, second, third, and fourth magnetoresistors comprises a corresponding serpentine structure.

28. The method of claim 26 further comprising forming a dielectric between the input strap and the first, second, third, and fourth magnetoresistors.

29. The method of claim 26 further comprising forming a set-reset coil in a third layer of the integrated structure.

30. The method of claim 29 wherein the second layer is between the first and third layers.

ABSTRACT

An integrated signal isolator is provided to isolate first and second circuits. First, second, third, and fourth magnetoresistors of the isolator are coupled together so as to form a Wheatstone bridge. The first second, third, and fourth magnetoresistors are arranged so that the Wheatstone bridge is immune to uniform external magnetic fields having any direction. An input strap generates magnetic fields across the first, second, third and fourth magnetoresistors in response to a signal from the first circuit so that the Wheatstone bridge provides an output to the second circuit that is commensurate with the signal from the first circuit.

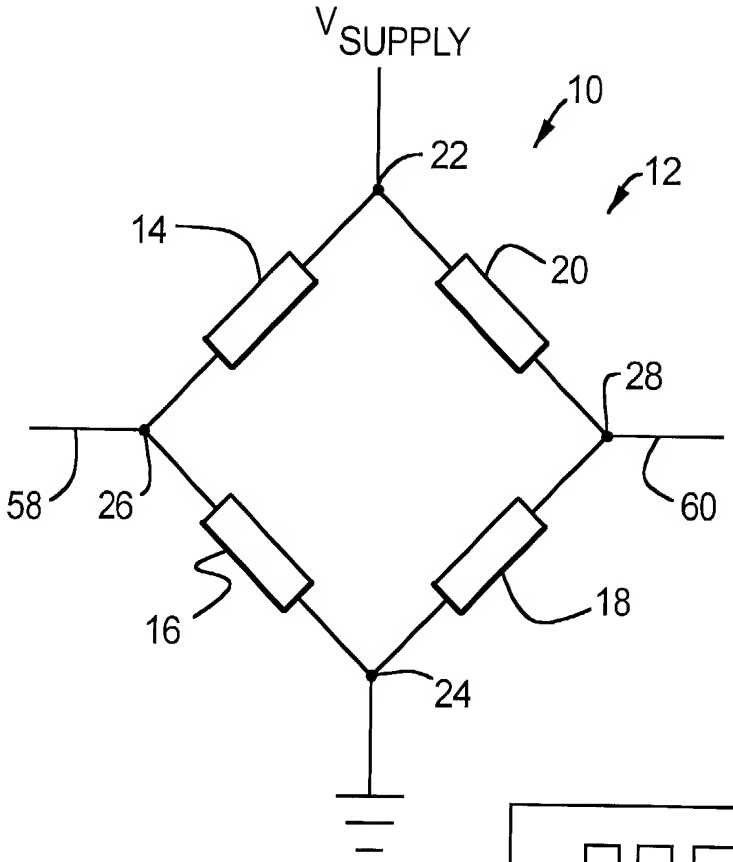
V SUPPLY
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FIG. 1

FIG. 5

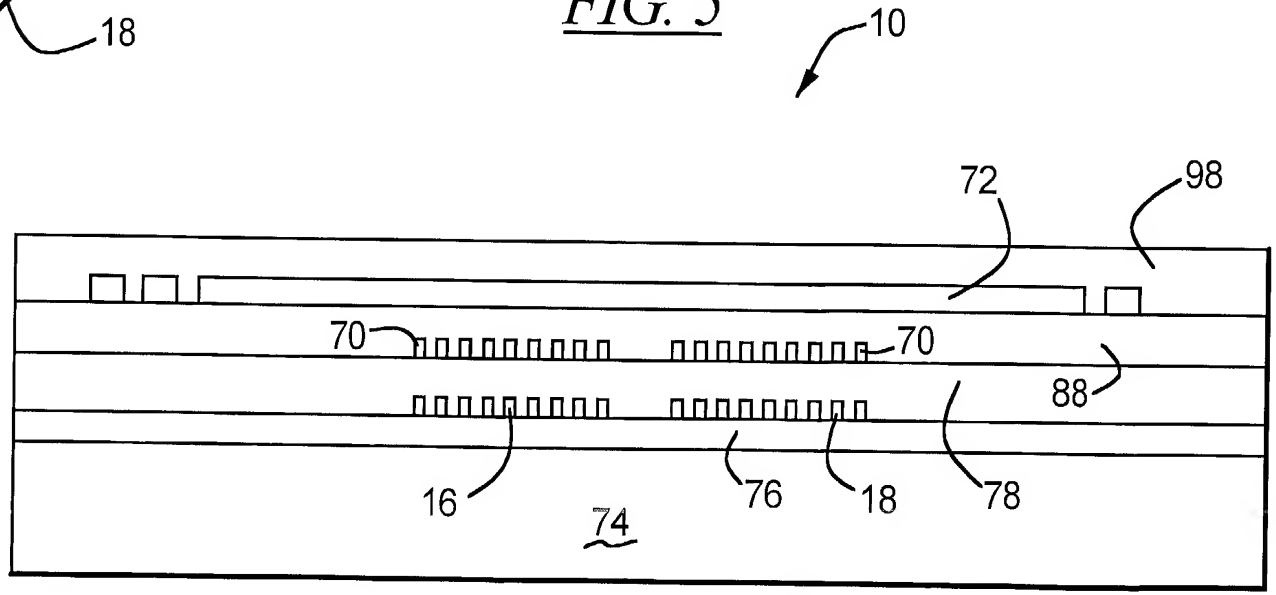
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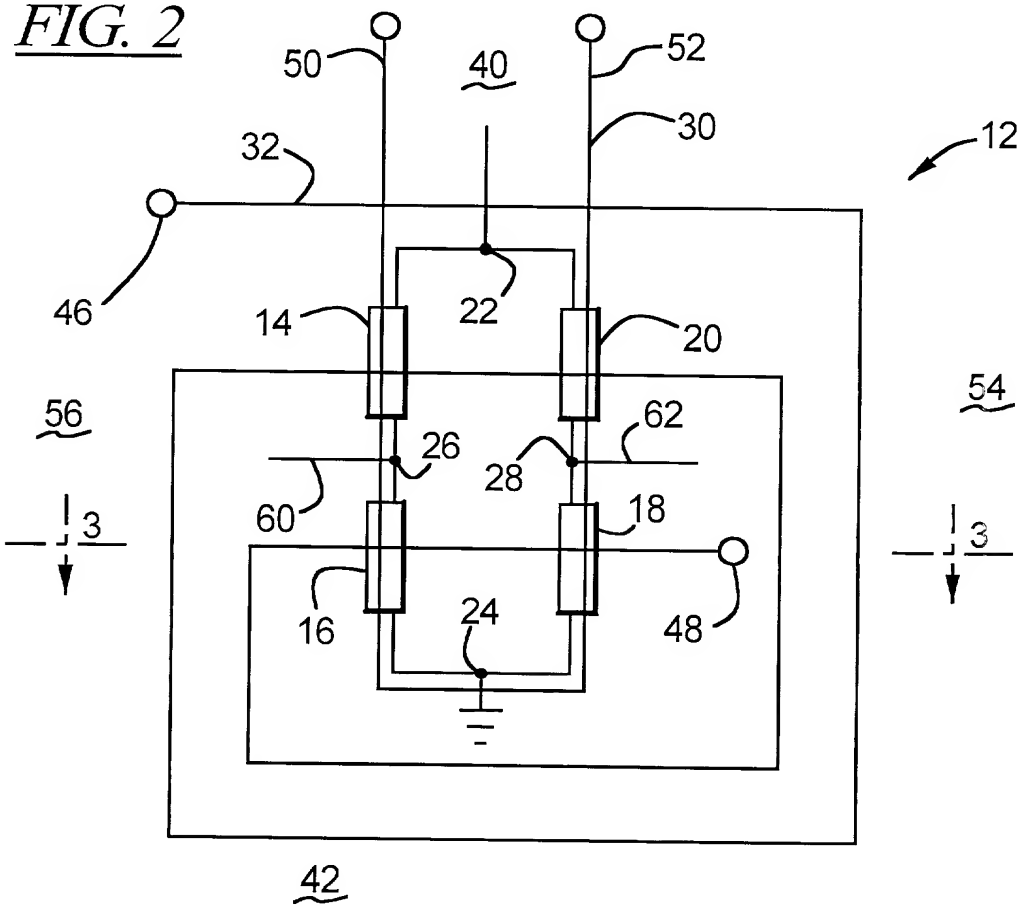
FIG. 2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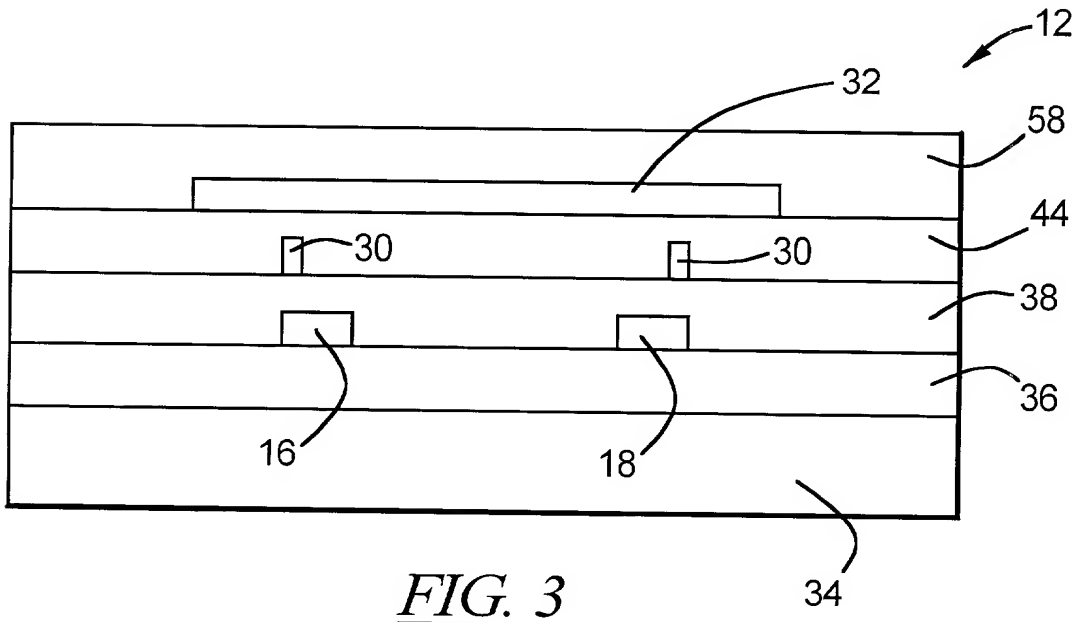
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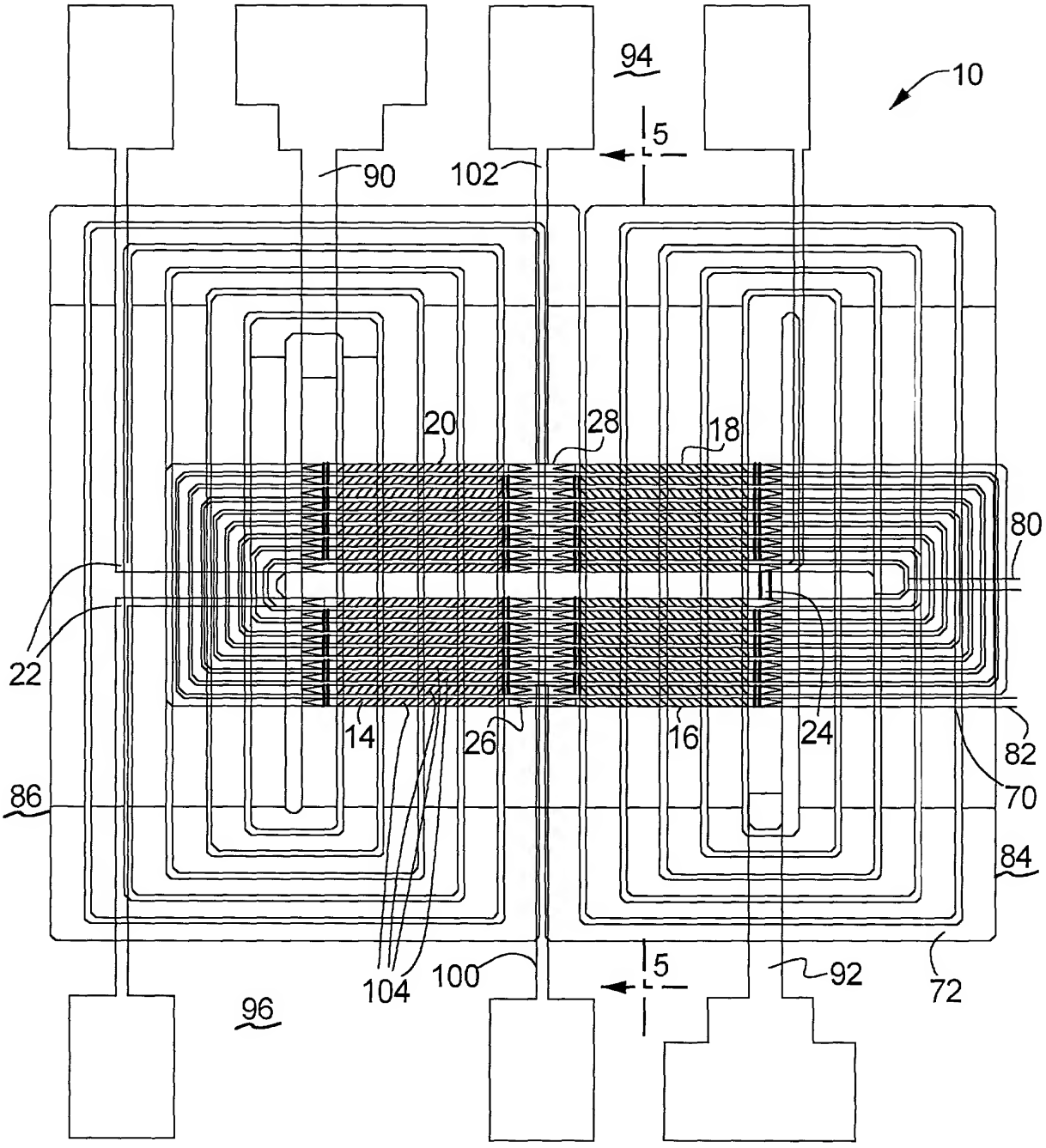
FIG. 3

FIG. 4



PATENT

Attorney Docket No.: H0002254

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

INTEGRATED MAGNETIC FIELD STRAP FOR SIGNAL ISOLATOR

The specification of which

(check one)
__X__ is attached hereto
_____ was filed on _____ as
Application Serial No._____
and was amended on _____.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).*

I hereby claim foreign priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			**Priority Claimed**	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby appoint all attorneys associated with Honeywell Customer No. 000128 and all attorneys associated with Schiff Hardin & Waite Customer No. 26574 to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith. Address all telephone calls to Dennis C. Bremer at telephone number (612) 951-6145.

Address all correspondence to Honeywell Customer No. 000128.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's Signature Hong Wan

Date 1/08/2002

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Citizenship USA

Full Name of Second Inventor _____

Inventor's Signature _____

Date _____

Residence _____

Citizenship _____

Full Name of Third Inventor _____

Inventor's Signature _____

Date _____

Residence _____

Citizenship _____

*Title 37, Code of Federal Regulations §1.56:

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all

information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.